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FACTORS THAT INFLUENCE HUMAN BEHAVIOR AND NEGATIVELY AFFECT ENERGY CONSUMPTION IN USMC GROUND UNITS DURING OPERATIONS

by

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September 2016

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The energy required to employ today's technologies on the battlefield is a logistical burden and a potential vulnerability. The thirst for energy is jeopardizing the self-sufficiency and security of the deployed warfighter. Improvements to equipment and the employment of renewable energy systems fail to address the impact that human behavior has on energy consumption and overlooks a tremendous opportunity. The Marine Corps' return to its expeditionary posture as a fast, austere and lethal force requires that it come to terms with energy consumption. The data and analysis presented in this thesis identifies behavioral trends and indicates that significant energy savings can be obtained through a concerted effort and behavior-change strategy that includes training and education, policy and planning, leadership and communication to improve individual and organizational awareness of the importance of efficient and effective use of energy. In particular, opportunities are available for significant improvement in the use and employment of generators, environmental control units and vehicles. Energy-related behavior changes within the operational environment can have a positive impact in several areas to include improved energy security, greater self-sufficiency, increased operational reach and fewer casualties from force protection of fuel resupply convoys.

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FACTORS THAT INFLUENCE HUMAN BEHAVIOR AND NEGATIVELY AFFECT ENERGY CONSUMPTION IN USMC GROUND UNITS DURING OPERATIONS

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ABSTRACT

The energy required to employ today's technologies on the battlefield is a logistical burden and a potential vulnerability. The thirst for energy is jeopardizing the self-sufficiency and security of the deployed warfighter. Improvements to equipment and the employment of renewable energy systems fail to address the impact that human behavior has on energy consumption and overlooks a tremendous opportunity. The Marine Corps' return to its expeditionary posture as a fast, austere and lethal force requires that it come to terms with energy consumption. The data and analysis presented in this thesis identifies behavioral trends and indicates that significant energy savings can be obtained through a concerted effort and behavior-change strategy that includes training and education, policy and planning, leadership and communication to improve individual and organizational awareness of the importance of efficient and effective use of energy. In particular, opportunities are available for significant improvement in the use and employment of generators, environmental control units and vehicles. Energy-related behavior changes within the operational environment can have a positive impact in several areas to include improved energy security, greater self-sufficiency, increased operational reach and fewer casualties from force protection of fuel resupply convoys.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACE	aviation combat element
CE	command element
CLB	combat logistics battalion
COA	course of actin
COC	combined operation center
COP	combat outpost
DOD	Department of Defense
DOTMLPF-P	doctrine, organization, training, material, leadership and education, personnel, facilities and policy
ECU	environmental control unit
EEAP	enhanced equipment allowance pool
ESD	exercise support division
FOB	forward operating base
GCE	ground combat element
IED	improvised explosive devise
ITX	integrated training exercise
kW	kilowatt
LCE	logistics combat element
LOC	logistics operation center
LVSR	logistics vehicle system replacement
MAGTF	Marine Air-Ground Task Force
MCAGCC	Marine Corps Air-Ground Combat Center
MCRP	Marine Corps Reference Publication
MCWP	Marine Corps Warfighting Publication
MEF	Marine Expeditionary Force
MEU	Marine Expeditionary Unit
MOS	military occupational specialty
MPG	miles per gallon
MTVR	medium tactical vehicle replacement
ODS	operator-driver simulator

OP	observation post
PCC	pre combat check
PCI	pre combat inspection
SME	subject matter expert
SOP	standard operating procedure
TTP	tactics, techniques and procedures
USMC	United States Marine Corps
WTI	weapons and tactics instructor course

EXECUTIVE SUMMARY

During the wars in Iraq and Afghanistan the United States Marine Corps (USMC) experienced substantial increases in energy use, seeing a 250 percent increase in the use of radios, a doubling of the number of vehicles and a tripling in the number of computers employed (United States Marine Corps 2011, 7). This thirst for energy presents a logistical burden and jeopardizes the self-sufficiency and security of the deployed warfighter (Ward and Captain 2009). To remain effective, it is important to minimize this vulnerability and ensure it does not undermine the operational and tactical advantages United States (U.S.) Forces possess.

Improvements to equipment and the employment of renewable energy systems are viable approaches to reduce energy consumption but fail to address the impact human behavior has on energy consumption. By expanding the spectrum over which increased fuel efficiency and fuel savings can be realized to include non-materiel solutions influenced by human behavior in addition to materiel solutions, greater benefits can be achieved. This thesis collects reports from real world operational environments and USMC training environments, capturing data on the employment of energy producing and energy consuming devises and related user behaviors. The data is analyzed to identify trends in behaviors and the causal factors that result in energy inefficiencies in order to identify potential solutions to improve energy efficiency within USMC ground units. The observations captured in these operational environments revealed excessive and inefficient energy expenditures were occurring in the use and employment of generators, environmental control units (ECUs) and vehicles.

Employment of generators to support electrical loads were often observed operating at approximately 30 percent of their designed capability requiring more assets to be used than required and consuming more fuel than necessary. Poor planning was the primary factor resulting in the poor employment of generators. The inefficient employment of ECUs was an additional issue commonly observed throughout the operational environment. Data collected found that for an infantry battalion, 78 percent of the electricity consumed was from the operation of ECUs (U.S. Marine Corps Forces, Pacific Experimentation Center 2013a, 9). Often spaces were cooled to excess or the spaces being conditioned had openings that allowed conditioned air to escape, diminishing the ECU's effectiveness and wasting energy. Poor awareness of the impact of these practices and the inattention of leadership are the behaviors believed responsible for these actions. The final category of inefficient energy behaviors analyzed is vehicle use. Vehicles consume 70 percent of the fuel required for operating ground units (Shields 2016, 26). A fractional reduction in the energy consumed by vehicles can have significant benefits by increasing how long units can operate or maneuver before resupply is required. Observations captured during training exercises identified excessive idling and inefficient vehicle use as common occurrences. Preparing for movement, vehicles were observed to idle for 90 minutes prior to departure. Situations of inefficient vehicle use also occurred such as using the medium tactical vehicle replacement (MTVR) to recharge gun batteries rather than using a more fuel efficient generator (Adamo and Lockhart 2014d, 2–4). Poor planning and awareness are two of the factors that contribute to unnecessary fuel consumption from vehicles.

The Marine Corps' return to its expeditionary posture as a fast, austere and lethal force requires that it come to terms with energy consumption. Advances in equipment alone overlook a tremendous opportunity. The data and analysis presented in this thesis indicate significant energy savings can be obtained through a concerted effort and behavior change strategy that includes training and education, policy and planning, leadership and communication to improve individual and organizational awareness of the importance of efficient and effective use of energy. Reducing energy consumption can have a positive impact in several areas to include improved energy security, greater self-sufficiency, increased operational reach and fewer casualties from force protection of fuel resupply convoys.

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I. INTRODUCTION

The effectiveness of the United States Military can be largely attributed to technology superiority. Technology, in spite of its many and perhaps immeasurable advantages has disadvantages as well. The energy demands associated with the technologies that contribute to the U.S. Military's effectiveness create logistical burdens and potential vulnerabilities. To remain effective, it is important to minimize those vulnerabilities and ensure they do not undermine the operational and tactical advantages created by technological superiority. By understanding how and where energy is consumed on the battlefield, opportunities to limit the energy burden and reduce potential vulnerabilities can be identified.

There are multiple ways to conserve energy. One approach is to increase the energy efficiency of the equipment. The challenge associated with improvements to energy efficiency is ensuring that those changes do not degrade performance. Another way to reduce the energy consumption is through the use of renewable energy sources such as nuclear, solar and wind energies. Employing systems that harvest and use renewable energy can reduce the logistical burden of energy on the battlefield. Behavior changes can also reduce energy consumption. Simple approaches such as turning off lights or vehicles when not in use or selecting appropriately sized energy sources for the specific need can result in significant energy savings. Of significant importance is reducing energy consumption without adversely impacting mission effectiveness. At the surface, changing human behavior seems to be a viable and even inexpensive way to save energy. Unfortunately, changing behavior to reduce energy expenditures is a complicated endeavor.

Instituting change within government agencies presents unique challenges compared to private sector companies but positive change within the government can be accomplished with the appropriate strategies (Ostroff 2006, 141). Changing behaviors related to energy use within the Marine Corps is viewed as analogous to instituting change within an organization. Improving behaviors and the perceived importance of energy requires an understanding of the factors that can influence not only the individual but the organization as a whole. By identifying the factors that influence human behavior and negatively affect energy consumption in United States Marine Corps (USMC) ground units during operations, targeted actions can be taken to affect positive behavioral change and lessen the energy burden on the battlefield.

A. PURPOSE

The challenge of satisfying the logistics requirements on the battlefield is not new. Previous conflicts such as the Second World War, Korea and Vietnam have focused on rations and ammunition as enablers for sustained military operations. The wars in Iraq and Afghanistan led to the realization by U.S. leaders and strategists that energy is also a key enabler and needs to be used wisely (Ward and Captain 2009; Carfrey 2009). The purpose of this research is to assess the factors that influence behaviors within the Marine Corps and adversely affect energy consumption. This thesis identifies and analyzes the behaviors that result in energy inefficiencies so that recommended strategies for improvement can be determined.

B. RESEARCH APPROACH

The systematic approach for this thesis begins with a brief overview of the Marine Corps as an organization. With a basic knowledge of the USMC organization, the research progresses to capture the impact energy usage has in the operational environment and the vulnerability it poses to security. Next, an examination of methods used for managing organizational change is performed with the goal of identifying those methods applicable to the USMC. Knowing how change can be successfully implemented within an organization having similarities to the Marine Corps provides insight into the types of organizational change strategies that are more likely to be successfully integrated within the USMC. At this point the research transitions to a summary of collected data that includes where energy is consumed and inefficient uses resulting from human behavior. The data is analyzed to gain an understanding of the specific factors that influence human behavior and negatively affect energy consumption in USMC ground units during operations. Finally, trends are identified and methods that may help affect positive behavioral changes are discuss and presented as opportunities for improvement.

C. BACKGROUND

The USMC has long been an agile, self-sufficient fighting force tasked with protecting U.S. interests (United States Marine Corps 2011, 3). The success of the USMC can be attributed in part to its organizational structure (United States Marine Corps 2015, 1–1). Recent conflicts have led to the realization that energy consumption on the battlefield has seen a dramatic increase. This thirst for energy is jeopardizing the self-sufficiency and even the security of the deployed warfighter (Ward and Captain 2009). Understanding the organization and culture of the USMC and how energy consumption can become a security vulnerability is a necessary starting point before further analysis of the problem.

1. USMC Ethos and Organization

Each branch of service within the U.S. Department of Defense (DOD) has its own area of strength. The Air Force commands the skies, the Navy has domain of the seas and the Marine Corps is tailored to operate within the world's littorals. Part of what helps establish the Marine Corps' identity and separates it from other U.S. Military organizations, beyond its mission, is its rich culture and organizational structure.

a. Being a Marine

Many occupations require an appropriate balance of knowledge, skill and mindset. One or even two of these attributes without the third is often insufficient. For example, geriatric care givers require not only knowledge and skill but a significant degree of compassion to be successful. In the case of a Marine, a special spirit is required in addition to mental and physical toughness. Marines fashion themselves as different from their brethren in the sister services and "are convinced that, being few in number, they are selective, better, and above all, different" (Krulak 1984, 155). Those who become Marines tend to be in search of something more than mere service to one's country. Being a Marine is to possess the Marine ethos. There are many aspects that contribute to the spirit and mindset of an individual who calls oneself Marine, and include training, core values, naval character and expeditionary mindset.

(1) Core Values

There are three fundamental core values engrained within everyone who earns the title Marine. Honor, courage and commitment constitute the foundation upon which all other behavior is based. Honor guides moral and ethical behavior. An individual with honor does not lie, cheat, steal or tolerate those who do. Courage consists of the moral fiber and physical strength ingrained during training that helps one persevere during times of challenge. Commitment pertains to dedication and persistence required to excel in every task that is undertaken (United States Marine Corps 2014, 1–6).

(2) Training

For any organization to be effective it must operate as a cohesive unit. In addition to a core set of skills, teamwork, communication and planning are all essential. In the military, training is provided to teach these attributes in addition to identifying their importance. From the first training environment the Marine Corps teaches everyone to be a rifleman. Officers and enlisted alike, male and female, regardless of what future military occupational specialty (MOS) is assigned, every Marine is first a rifleman and therefore has been taught how to shoot accurately. Establishing this fundamental skill in addition to other basic infantry skills provides all Marines with the knowledge that they are the same and provides "a sense of cohesiveness enjoyed by no other American service" (Krulak 1984, 155).

(3) Naval Character and Expeditionary Mindset

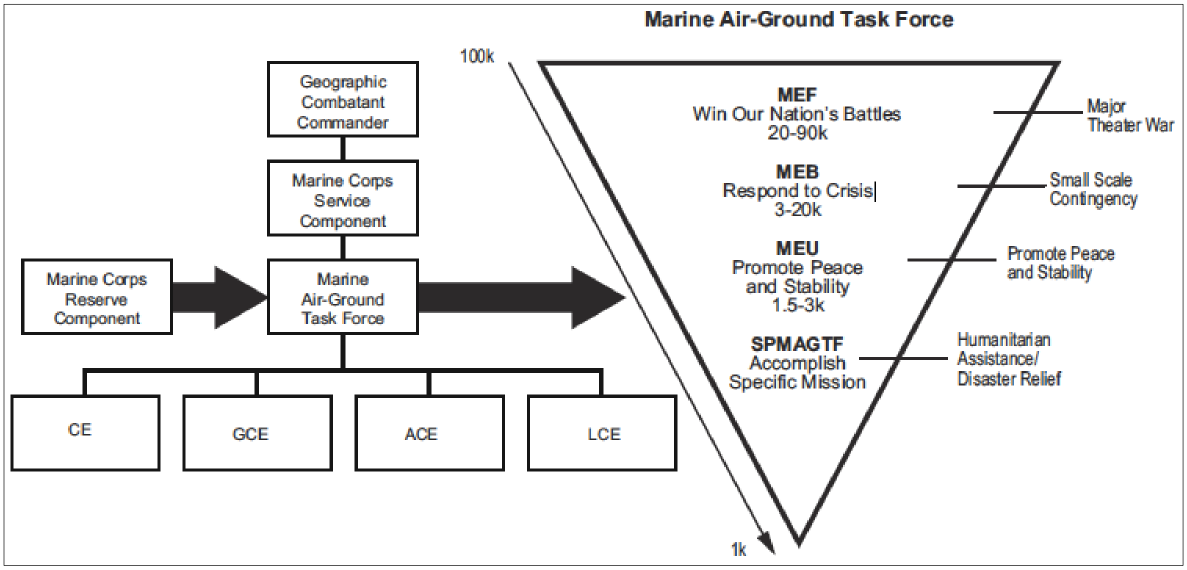
Another characteristic unique to the USMC is their amphibious nature. Early Marines were part of the ship's company on board ships but were also required to go ashore as an expeditionary force and therefore had to possess both maritime and soldierly skills. Today, the USMC remains rooted in its naval character with its partnership with the Navy. The expeditionary nature of going ashore on foreign soils also persists within the mindset of Marines. As soldiers from the sea, being a Marine "is more than the mere ability to deploy overseas when needed. It is an institutional imperative" (United States Marine Corps 2014, 1–10). As described in Expeditionary Force 21, the document that lays out the Marine Corps vision, the USMC expeditionary mindset can be simply summarized as fast, austere and lethal. These three words shape how the USMC trains and operates and is yet another way in which Marines differentiate themselves from the other services.

b. Marine Air-Ground Task Force Organization

A Marine Expeditionary Unit (MEU) is often considered America's 911 force (USMC 2014) and is tailored as a crisis response force. MEUs are specifically configured Marine Air-Ground Task Forces (MAGTFs) that are forward deployed and self-sufficient. When structured as an operational unit, the Marine Corps is organized as MAGTFs. As described in Marine Corps Reference Publication (MCRP) 5–12D, MAGTFs are "integrated, combined arms forces that include air, ground, and logistics units under a single commander." They are organized, trained, and equipped to respond to a diverse set of missions ranging from humanitarian assistance and disaster relief as was seen following the 2010 earthquake in Haiti (Faram 2010, 12) to much larger, theater engagements as seen during Operation Iraqi Freedom following the events of September 11, 2001.

An advantage to the MAGTF structure is that it is highly scalable. Regardless of the size, a MAGTF, as depicted in Figure 1, contains four components: a command element (CE), a ground combat element (GCE), an aviation combat element (ACE), and a logistics combat element (LCE). Each of these elements satisfy a specific role. Although each component has its own role, these components work together to achieve the assigned mission.

Figure 1. MAGTF Key Elements

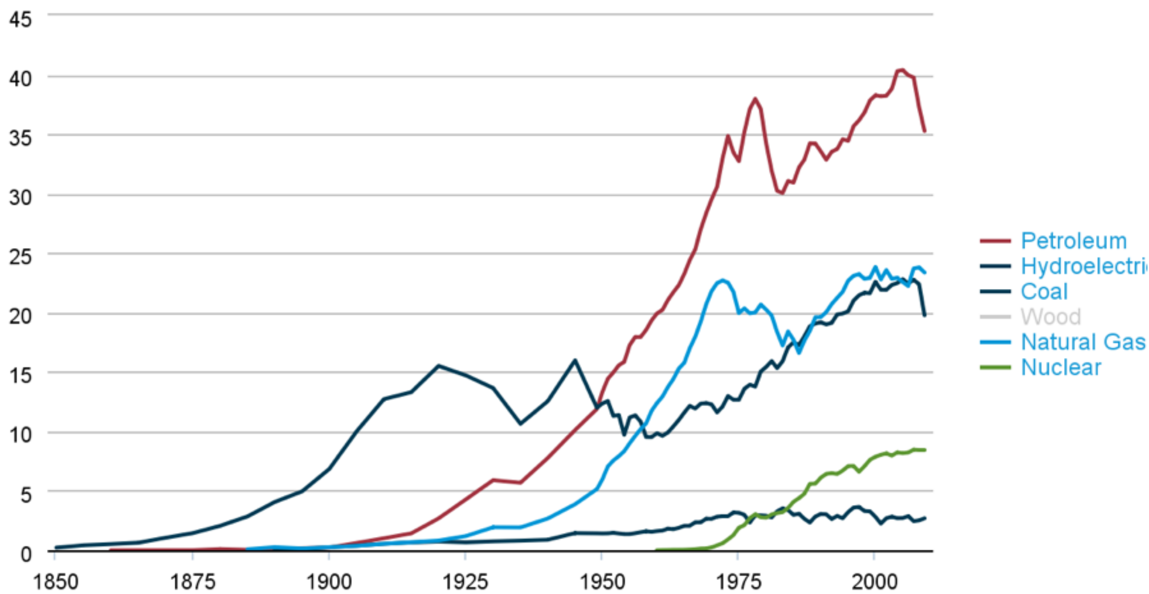


Source: United States Marine Corps, 2015, *MCRP 5–12D: Organization of the United States Marine Corps*, Washington, DC: Department of the Navy, Headquarters, United States Marine Corps.

2. Energy Consumption Trends

Energy consumption in the United States as seen in Figure 2 has continued to grow over the past several decades. From 1995 to 2005 U.S. energy consumption grew by approximately 10 percent (U.S. Energy Information Administration 2010, 40). Energy use in the U.S. military has seen a similar increase. During the period from 2001 to 2011 which included the war in Iraq and Afghanistan, the USMC has seen substantial increases in energy consumption. By the end of 2011, the Marine Corps had experienced a 250 percent increase in the use of radios, a doubling of the number of vehicles used and a tripling in the number of computers. To compound the logistical requirement to support the increased assets, the additional vehicles needed to support the warfighter were heavier and across the fleet resulted in a 30 percent reduction in fuel efficiency (United States Marine Corps 2011, 7). A portion of the increase in energy consumption is attributable to the theater of operation. Unfortunately, the rate at which energy consumption has increased has created several issues and concerns. Fortunately, military leadership at the highest levels have recognized the dramatic increase in energy consumption and have taken steps to curb the trend with new strategies for reducing energy consumption.

Figure 2. History of Energy Consumption in the United States.



Adapted from Department of Energy, 2010, “Annual Energy Review 2009,” U.S. Energy Information Administration: Department of Energy.

3. Energy Security

Many operational units treat energy as a commodity that will always be readily available (Department of Defense 2011, 3). The U.S. military’s reliance on energy has become a significant vulnerability, both operationally and with respect to casualties. The enemy is aware of this weakness and seeks to exploit the vulnerability, limiting our freedom to maneuver (Ward and Captain 2009, 15).

The preponderance of the U.S. military’s operational energy is satisfied by petroleum-based liquid fuel, referred to as JP-8. In Afghanistan, fuel resupply was conducted either by air or vehicle convoys. Convoys, as seen in the Figure 3, present themselves as targets as they travel along thousands of miles of unsecured roads (Herbert 2011, 5). Further, convoys require personnel for physical security to limit attack by hostiles or improvised explosive devises (IEDs). During a 10-month period ending in October 2011, one brigade assigned to support logistical operations such as fuel and water convoys had 12 warfighters killed and awarded 78 purple hearts (Herbert 2011, 5). Personnel use for physical security of fuel convoys detracts from offensive missions.

Aerial resupply eliminates the potential for IEDs but is 10 times as expensive as vehicle convoys (Herbert 2011, 6).

Figure 3. Fuel Convoy, Afghanistan

Source: C. Ward and T. Captain, 2009, *Energy Security: America's Best Defense*, Deloitte LLP, New York.

The vulnerabilities associated with vehicle convoys result in increased casualties and disrupt operational capabilities. On one occasion, a combat outpost (COP) operating in Afghanistan had to prioritize power requirements to essential tasks since their remaining fuel "was down to 10 gallons and [they] had to make the supply last for three days" (Herbert 2011, 13). Fortunately, leadership has taken notice of the dramatic increase and reliance on energy consumption and the resultant vulnerability.

On August 13, 2009, Commandant of the Marine Corps, General James Conway spoke at the Hyatt Regency in downtown Washington, DC, for the Marine Corps energy summit. The Commandant concluded his address to the audience by saying "We will be more energy efficient. We have to be" (Carfrey 2009). The speech and in particular the conclusion by the senior Marine Corps leader indicates the importance of energy and how it is used. In 2011, further recognizing that energy security is a vital component for national security the DOD published Energy for the warfighter: Operational Energy Strategy. The goal of this strategy is to ensure that U.S. Forces will have the energy resources required to meet 21st century challenges. Further, each service, Army, Navy, Air Force and Marines have each identified and published philosophies for addressing energy security.

4. Managing Organizational Change

Changing the way Marines view and use energy requires an understanding of the Marine Corps' culture and the various factors that affect change. Behavioral changes are influenced by both organizational factors and individual factors (Tudor et al. 2008, 427). Understanding why these factors affect an individual's desire to change is essential to identify how best to implement change within an organization such as the Marine Corps.

a. Organizational Factors

Organizational factors can influence either willingness or resistance to certain behaviors. As defined by Pheysey (2002, 1) organizational behavior is how an organization works and how the people within them act. An organization's focus and its structure both influence behavior. An organization's focus or mission has been seen to be a significant influence on the personnel within the organization (Tudor et al. 2008, 433). This suggests that unless the organization has a concerted focus on energy conservation, individuals will be less inclined to follow suit. Tudor also indicates that organizational structure impacts individual behavior. A hierarchical leadership structure with multiple levels makes conveyance of a common and consistent message, such as a focus on energy conservation more difficult to communicate. Organizational factors such as organizational focus and structure both influence the behavior of the individuals within the organization and need to be taken into consideration for a change strategy to be effective.

b. Individual Factors

In addition to organizational factors, individual factors also impact behavior and the degree of willingness or resistance personnel will have toward change. Factors such as knowledge and attitudes contribute to the individuality of a person. In diverse organizations such as the USMC these factors influence how the behavior of one individual may differ from others. Having knowledge in a subject area has been shown to be a predictor of behavior. Vining and Ebreo (1990, 56) conducted a study of recycling and nonrecycling households and found that households that knew how to recycle were more likely to participate in recycling programs. Attitudes represent another individual factor that affects behavior. A study of household energy consumption completed by Brandon and Lewis (1999, 75) observed that individuals with positive environmental attitudes were more likely to improve their energy consumption behaviors. Although other factors such as income level contribute to individual attitudes and subsequently behaviors, Brandon and Lewis (1999, 76) encourage the dissemination of "information designed to promote energy consciousness." Examples demonstrating how individual behaviors have been positively influenced in other situations can be considered as approaches that may be applicable to the Marine Corps.

c. Behavioral Change Strategies

Following an understanding of the various factors that affect individual behaviors within an organization, an assessment of the strategies that can be implemented to effect change can be considered. Several strategies are available to include communication, leadership, education and training (Caldwell 2003; Kotter and Schlesinger 2008; Ostroff 2006). While each of these approaches can prove effective for implementing change within an organization, a strategy that combines several of these approaches is generally more effective. Communicating the need and benefits of change with clear and consistent goals is critical in affecting change within an organization. The study by Schelly et al. (2011, 333) revealed that "communication about successful efforts was reported to enhance efficacy and inspire additional change." The leadership within an organization has an essential role in implementing change. As the leadership structure is a factor affecting organization, the way in which leadership reacts to change also impacts how subordinate individuals will react. Leadership at all levels of the hierarchical structure need to demonstrate support of the need for change and communicate its importance throughout. Education and training are two related strategies that differ in the degree of knowledge imparted to the individual. As described by Vining and Ebreo (1990, 55), both recycling and nonrecycling families who were informed or educated on the benefits of recycling would concede its importance but the families who received instruction or training on how to recycle were more likely to participate in the practice. This suggests that while general information about the importance of energy conservation increases the understanding of its importance, training is often necessary to increase the probability for individuals to change their behaviors. Communication, leadership, training and education each contribute to changes in individual behaviors but a combination of these strategies increases the likelihood for positive changes in human behavior.

5. DOD Energy Initiatives and Goals

A key starting point for any change process is a determination that change is a necessary element for the well-being or improvement of the organization. During the conflicts in Iraq and Afghanistan following the events of September 11, 2001, significant resources were required to provide fuel to support military forces. The logistical challenges and cost, both financially and in casualties were soon realized by strategists and leaders alike as a vulnerability. As a result, the DOD and each service organization has developed initial and overarching strategies for reducing the energy consumed within the DOD, on the battlefield and at home stations. In February 2011 the Marine Corps published its Expeditionary Energy Strategy and Implementation Plan to reduce dependence on fossil fuels in the operational environment (United States Marine Corps 2011, 5). Although development of overarching strategies such as the Marine Corps' "Bases to Battlefield" is a starting point, more is required to affect lasting change.

D. RESEARCH QUESTIONS

When the DOD identifies a capability gap the first step in the functional solution analysis is the completion of a doctrine, organization, training, materiel, leadership and education, personnel, facilities and policy (DOTMLPF-P) analysis. The DOTMLPF-P analysis identifies if a non-materiel solution can address the issue (Cenotes 2016). The research and analysis completed in conjunction with this thesis is not a complete DOTMLPF-P analysis but does seek to identify non-materiel solutions for improving energy use within the Marine Corps. Specifically, this thesis evaluates inefficient energy use of select systems within USMC ground units and answers the following research questions:

1. What are the factors that influence human behavior and negatively affect energy consumption in USMC ground units during operations?
2. Can behavior based energy savings be realized without sacrificing mission performance?
3. What benefits can be realized by changing human behavior to avoid unnecessary energy expenditures?

E. BENEFITS OF RESEARCH

Technological advancements focused on improving equipment to gain fuel savings and fuel efficiency fail to address the impact human behavior has on energy consumption. Understanding organizational and individual factors that influence human behavior and negatively affect energy consumption in USMC ground units during operations is necessary in order to identify opportunities for energy savings through human behavior. Reducing energy consumption will have a positive impact in several areas to include improved energy security, greater self-sufficiency, increased operational reach and fewer casualties from force protection of fuel resupply convoys. By expanding the spectrum over which increased fuel efficiency and fuel savings can be realized to include non-materiel solutions influenced by human behavior in addition to materiel solutions, greater benefits can be achieved.

F. CHAPTER SUMMARY AND RESEARCH ORGANIZATION

This chapter provides an overview of the heightened awareness and importance of energy use on the battlefield and discusses potential impacts that may be realized unless improvements are made. The purpose for this research is also presented, positing several research questions to be considered with the goal of understanding behaviors within the Marine Corps that negatively affect energy consumption so that relevant change strategies for improvement can be identified and ultimately, implemented. The following chapter conveys the findings of a literature review that leverages previous research on the topic of energy use within military operational environments. Chapter III covers the detailed research methodology, defines the scope and limitations and discusses the relevance of this research to systems engineering. Chapter IV is a presentation of energy related behavior data obtained from previous efforts and is followed by an analysis of the data identifying behavioral trends that negatively affect energy consumption in Marine Corps ground units. The final chapter contains conclusions, recommendations and areas for further research.

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II. LITERATURE REVIEW

During the past several years, the Marine Corps has supported multiple efforts in an attempt to achieve a holistic understanding of energy consumption in the operational environment. Many of the studies looked at benefits achievable with new equipment and present opportunities to quantify the potential return on investment (Carrier 2014; U.S. Marine Corps Forces, PEC 2013a; U.S. Marine Corps Forces, PEC 2013b). More recently, investigations regarding the impact that human behavior has on energy expenditures has occurred (Adamo and Lockhart 2014b; Adamo and Lockhart 2014c). Although the data is somewhat subjective, initial observations indicate several areas where opportunities for improvement exist.

The impact fuel consumption had on energy security experienced in Afghanistan, in terms of financial cost and casualties prompted the Marine Corps to investigate ways to reduce energy expenditures in the operational environment. Several studies were subsequently initiated. A modeling and simulation excursion completed in 2011 evaluated the potential benefit of environmental control units (ECUs) that were more energy efficient. An ECU provides either air conditioning or heat for work and billeting areas. The study concluded that a 10 percent improvement in efficiency of the ECUs employed throughout the Marine Expeditionary Force (MEF) Forward operating in Afghanistan would eliminate 79 tanker trucks of fuel annually with financial savings of $2.42 million (Bulanow et al. 2011, 58). In 2013 a limited operational assessment conducted during exercise Balikatan reported that the use of a "radiant barrier [in tents] alone reduced ECU energy consumption by 7.0 percent and helped maintain a high level of thermal comfort indoors during peak operating temperatures" (USMC Balikatan 2013, 9). These examples convey the potential benefits that additional or improved equipment may provide but new equipment requires capital investment.

In addition to examining the benefits that new equipment can provide, the Marine Corps is investigating the impact of human behaviors on energy expenditures. An assessment team tasked with observing behaviors that impact energy consumption during a USMC training exercise at Twentynine Palms, CA, witnessed several scenarios in which inefficient energy practices were occurring. One specific instance involved a convoy of vehicles that were left idling for approximately 45 minutes before departing while details of the movement were discussed (Adamo and Lockhart 2014a, 2). A separate team observing behaviors during the weapons and tactics instructor course (WTI) 2–15 witnessed the doorway flaps for several tents being left open even though the air conditioning was on. Interviews conducted with Marines regarding energy use yield responses such as “I doubt that Marines waste much energy” and “fuel’s not a concern” (Salem and Gallenson 2014. 15). These beliefs suggest that Marines do not share the same understanding, awareness or impact of how behaviors can negatively impact energy use in the operational environment. If Marines do not understand the importance of energy, it becomes incumbent on leadership within the organization to explain its importance and how energy impacts mission effectiveness. Education and communication are strategies that can be used to change behaviors (Kotter and Schlesinger 2008, 136). Many of the observations related to the effect human behavior has on energy usage indicates that there is a significant opportunity for improvement within the Marine Corps.

III. RESEARCH METHODOLOGY

The methods employed for this research are intended to capture information and data for analysis to gain insights that will help answer the research questions posed in this thesis. Information and data was collected from available sources with a preference for materials that were more recent and considered to be relevant or relatable to military environments.

This thesis collected reports that characterized the employment of energy producing and consuming devices in various settings. Reports of the real world operational environment of Afghanistan in addition to USMC training exercises taking place in the desert regions of the southwest United States and the tropical areas of Southeast Asia were gathered that captured the employment of energy producing and consuming devices as well as related user behaviors. The data contained within the collected reports was analyzed to identify trends in behaviors that result in energy inefficiencies. Following identification of the behavioral trends, an assessment of the factors believed responsible for the behavior was conducted. The final objective was to identify potential solutions to address the factors and improve energy efficiency of USMC ground units during operations.

A. SCOPE

In an effort to constrain the information and data to a manageable and comprehensible size, collected material was filtered for applicability to USMC ground units in an operational environment. Energy consumption for aviation and ship-to-shore movement are excluded from consideration for this research. The ground component of a MEU was identified and selected as an approximate and reasonable size. This size unit routinely trains in an operational settings and offers adequate information and data for consideration. Analysis of MEU size forces also affords the opportunity to consider how energy usage within MEU elements and sub-units is employed and perceived by individuals. Quantifying the impact behaviors have on energy consumption is outside the scope of this research. Although the elimination of specific behaviors may enable measureable and quantifiable energy savings, knowing the degree to which a behavior can be changed is dependent on many factors, making accurate predictions impractical in this thesis. The research efforts were focused for the purpose of determining: (1) the various factors that influence human behaviors that negatively affect energy consumption; (2) whether behavior based energy savings can be realized without adversely affecting mission effectiveness; and (3) the potential energy related benefits that may be realized by changing behaviors.

B. LIMITATIONS

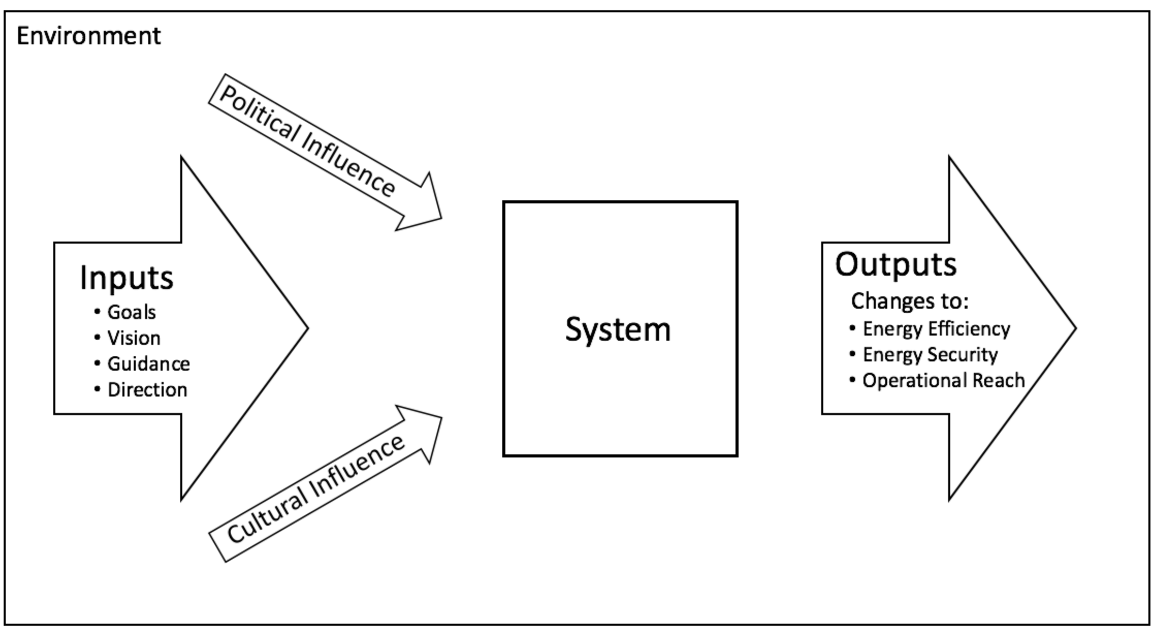
This section identifies the limitations that were realized during the course of this research. Although the data gathered has provided sufficient information to draw conclusions regarding the factors that influence human behavior and negatively affect energy consumption in USMC ground units during operations, quantifying the impacts would be very challenging. The information presented in the preponderance of reviewed reports consisted of naturalistic observations gathered on a non-interference basis. Naturalistic research evaluates behaviors as they occur in everyday life without interference from the observer or researcher (Stangor 2011, 128). Surveys and interviews revealed the attitudes and beliefs related to energy use within the organization. Since the observations of inefficient energy use occurred under naturalistic conditions, it is impossible to draw specific correlations between the behavior and the individual's beliefs. This consideration is especially relevant when mission performance is at stake and would typically be a higher priority than energy efficiency. The duration and seasonal timing of the exercises was also a limiting factor. The observations during WTI, integrated training exercise (ITX), Cobra Gold and Balikatan were collected over a relatively short time period of less than a month when temperatures warranted air conditioning rather than heating. The short duration of the exercises eliminates the ability to assess how seasonality may influence behaviors. Further, it cannot be known if cold weather would result in similar inefficiencies as occur during warm weather. A final limitation regarding recreation of this work is access to the collected data. Many of the studies and reports were completed for specific commands within the Marine Corps. As such many of these reports can only be obtained by contacting the sponsoring organization rather than internet and database searches.

C. SYSTEMS ENGINEERING

For the purpose of providing context and application for this research, systems engineering is an interdisciplinary approach to a technical effort employed to achieve desired goals such as improved system efficiency and effectiveness (Blanchard and Fabrycky 2011, 17–18). The system under consideration includes both the human operator and the machine. Stakeholder analysis, systems integration and a feedback loop are aspects of the systems engineering process that are considered to address the research questions.

A system's operation and resultant outputs are influenced by the environment and the inputs received. Figure 4 is a simple context diagram that illustrates some of the factors that may affect a system. In the example context diagram the system can represent a machine, software system, organization or some combination of these.

Figure 4. Context Diagram



The system under consideration for this research includes both the human operator and the machine. Operation of the system as a whole is affected by human behaviors. Behaviors, in turn are influenced by attitudes, beliefs and perceptions. The individual operator, while being part of the system itself is viewed as a stakeholder as well. Unit and organizational leadership within the Marine Corps, in addition to one's peers are also viewed as stakeholders who have the potential to influence the behaviors and decisions of the individual operator. Understanding the factors that influence human behavior regarding energy use is necessary to formulate strategies for changing behaviors and improving the efficient use of energy without affecting mission performance.

The implementation of strategies to effect change is analogous to instituting organizational change. Changing the way an organization acts can be complicated. Successful implementation of strategies to improve energy related behaviors will need to be carefully planned and integrated within and throughout the Marine Corps. Systems integration is the second aspect of the systems engineering process used in the research process for this thesis. Systems integration can be thought of as the joining of objects or processes to provide system level improvements (Langford 2012, 371). In this case, the process is the change strategy being considered to change behaviors in order to improve energy efficiency. The system is the operator and the energy consuming machine which he is part of. The machine can be any energy consumer such as an ECU, generator or vehicle. For the change strategy to be successful it must effectively join or fit with the system and organization.

Improving the efficiency and effectiveness of energy use in the USMC depends on a comprehensive understanding of the stakeholders, successful integration of a behavioral change strategy that is embraced by the organization and a feedback loop. The feedback loop is an important part of the systems engineering process. Communicating progress as a way of providing feedback regarding the effectiveness of the strategy enables leadership to refine and revise the strategy and improve the likelihood of affecting positive and enduring behavioral changes within the organization.

IV. PRESENTATION OF DATA

The data gathered in support of this research was collected from a variety of sources, with a preference for materials that are more recent, and were obtained from military exercises or considered to be relevant or relatable to military environments. When available, data from the Marine Corps operational environment is used. Data collected includes existing information in the form of observations, studies, assessments, surveys and interviews. Reports of the real world operational environment of Afghanistan in addition to USMC training exercises taking place in the desert regions of the southwest United States and the tropical areas of Southeast Asia were gathered that captured the employment of energy producing and consuming devices as well as related user behaviors. The Appendix includes a sampling of the data collected during Marine Corps training exercises. Observations were collected using naturalistic research techniques. Some of the studies established controls in an attempt to quantify how various changes could impact energy consumption while other studies considered individual responses from questions, surveys and interviews in an effort to make qualitative assessments of how existing beliefs and attitudes affect behaviors and impact energy use. The methods used to gather the data indicate that there are many methods to gather information related to efficient use of energy and seemingly all are able to glean some insight on the various contributors affecting energy use. The information gathered for this thesis was also collected from different institutions and agencies with varying controls and methods. The general takeaway is that many opportunities exist to employ methods in which energy savings can be realized from both changes in materiel solutions and human behavior which is the focus of this thesis.

A. ENERGY CONSUMERS

Considering the goals and objectives set forth by the USMC in its Expeditionary Energy Strategy and Implementation Plan (United States Marine Corps 2011), several of the studies that were reviewed investigated the various areas within the operational environment where energy is used. As previously described, this thesis focuses on ground operations where energy is consumed excluding ship-to-shore movements. The data collected from observations in both training environments and real world operational environments indicate that energy consumers can be broken down into two broad categories: electrical generation and vehicle operation.

The first of the two categories where significant energy consumption occurs is in electrical generation. Electrical generation consists of the use of liquid fuel to produce electricity. Generators represent the primary means by which electrical power is generated. From the information gathered, the largest consumer of electrical energy is from ECUs. These provide either air conditioning or heat for work and billeting areas. Data collected during exercise Cobra Gold found that for an infantry battalion, 78 percent of the electricity consumed was from the operation of ECUs (USMC Cobra Gold 2013, 9). Other assets that rely on electrical power for operation include lighting, computers, water purification, refrigeration, communication assets, sensor systems and miscellaneous plug loads.

Vehicle operation is the second category in which significant energy consumption occurs. The ground movement of personnel and equipment is a necessary and routine aspect of military operations. Vehicles are also relied upon to provide power for command and control systems while on the move and sometimes while in static scenarios. Energy modeling of small unit scenarios indicates that vehicles can consume as much as 70 percent of the total fuel required for ground unit operations (Shields 2016, 26).

B. INEFFICIENT ENERGY USE

During the Marine Corps energy summit in August of 2009, General James Conway, Commandant of the Marine Corps emphasized the importance that operational forces become more energy efficient (Carfrey, 2009). These comments precipitated multiple efforts that took place during the time period from 2009 through 2015 and continue today. Some efforts were conducted within the real world operational environment of Afghanistan while other were conducted during training exercises taking place in the desert regions of the southwest United States and the tropical areas of

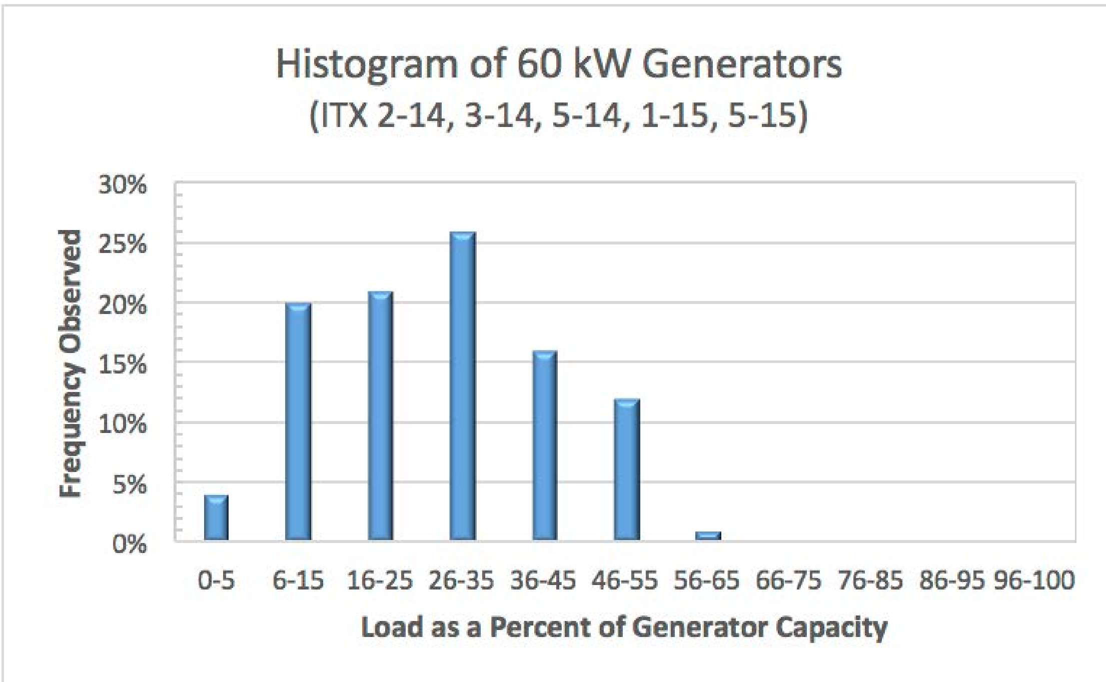
Southeast Asia. The observations captured in these operational environments revealed several areas in which inefficient energy use was prevalent. Three areas in particular where excessive and inefficient energy expenditures were occurring were in the use and employment of generators, ECUs and vehicles.

1. Generators

Many of the tactical assets used by the military require electrical power to operate. Generators are the primary systems relied upon for electrical power generation in the operational environment. Systems reliant on electricity for operation include communication assets, computers, lighting, water purification, refrigeration, sensor systems, battery chargers and other miscellaneous plug loads. Generators employed to support electrical loads were often observed operating far below their designed capability consuming fuel at less than optimal rates. During the Marine Corps' ITX conducted at Twentynine Palms, CA, in March 2014 the generators located at the artillery unit's headquarters battery and maintenance area were observed to operate well below capacity. A 10 kilowatt (kW) generator was supporting an average load that was less than 10 percent of capacity while a 30 kW generator was operating at an average load of less than 30 percent capacity. Additional observation of 5 separate generators employed during the Weapons and Tactics Instructor (WTI) Course at Yuma Proving Grounds, AZ, in April 2014 revealed that each was underutilized (Adamo and Lockhart 2014a, 2–3). None of the generators observed on these occasions were operating above 30 percent capacity. Similar situations of underutilized generators were observed in Afghanistan as well. A collection of data captured from over a dozen locations that included forward operating bases (FOBs), COPs and observation posts (OPs) revealed that every generator "observed was operating below its designed efficiency point. Most were below 25 percent of their capacity" (U.S. Army REF 2011, 5).

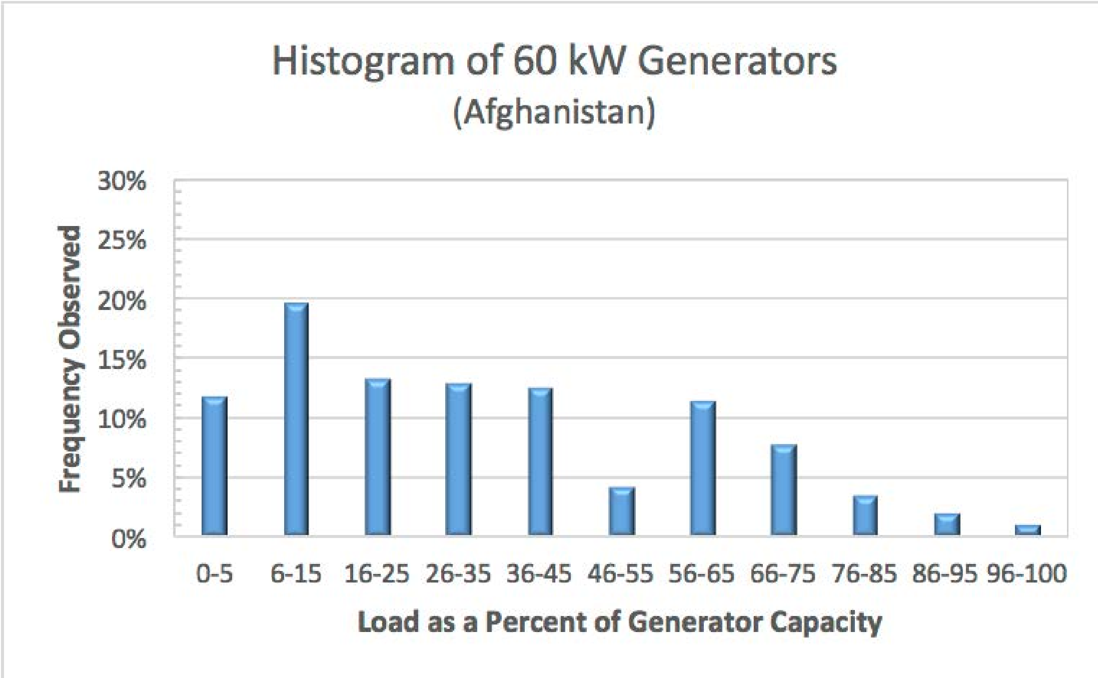
Over the course of two years, generator usage data was collected during seven separate ITXs. The histogram in Figure 5 represents the data collected for the 60 kW generators employed. It illustrates the load capacity at which the generators operated and the corresponding frequency of occurrence. Data was likewise captured for generators employed at various sites in Afghanistan during the summer of 2011. Figure 6 represents the load conditions collected on 281 different 60 kW generators employed and illustrates the frequency of the various load conditions. Note that during the ITX events fewer than 5 percent of generators operated above 55 percent capacity and during operations in Afghanistan approximately 25 percent of generators operated above 55 percent capacity.

Figure 5. USMC Generator Utilization During ITXs



Adapted from Naval Surface Warfare Center, Carderock, 2016a, *Generator Usage Data*, Washington, DC: USMC Expeditionary Energy Office.

Figure 6. USMC Generator Utilization in Afghanistan



Adapted from Naval Surface Warfare Center, Carderock, 2016a, *Generator Usage Data*, Washington, DC: USMC Expeditionary Energy Office.

2. Environmental Control Units

Environmental control units (ECUs) provide either air conditioning or heat. The ECUs employed by the military are ruggedized to withstand the harsh environmental conditions present in operational environments and are available in multiple sizes to support billeting and work spaces of various sizes. Inefficient employment of ECUs was observed on many occasions during different exercises. These scenarios can be loosely categorized into two groups described as improper containment and excessive cooling.

Improper containment refers to employment of ECUs for spaces that have doors or tent flaps open, poor connections where conditioned air is fed into the spaces or excessive duct lengths between the ECU and the space conditioned. Each of these scenarios require the ECUs to run at higher loads, consuming more energy and fuel than otherwise necessary. Figure 7 illustrates significant duct lengths between the ECU and the tents being cooled. Data collected "along the ECU air distribution system [showed] a very large temperature rise between the supply end and the distribution end—as much as

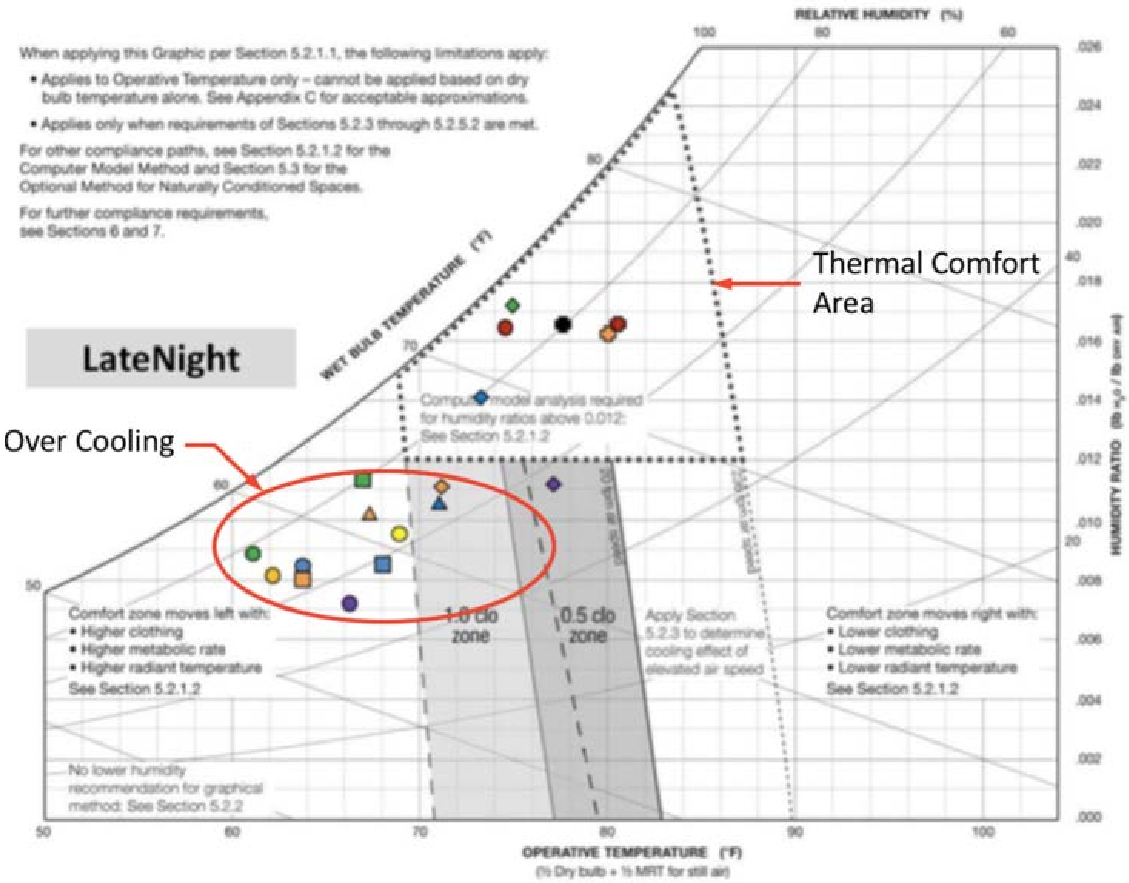
18 [degrees Fahrenheit] during the peak heat of the day" (Miller 2014, 16). Less quantifiable inefficiencies occurred as well. During an exercise in Yuma, AZ, the majority of tents from one unit did not have their entryways closed or secured when the ECUs were operating. Similar instances of inefficiencies were observed during the same exercise where "command tents were commonly oversized for the amount of space needed or used" (Adamo and Lockhart 2014a, 1–2).

Figure 7. ECU Duct Losses

Source: Mark R. Miller, 2014, *Final Report 04 – PACOM Operational Energy Study*, Arlington, VA: Office of Naval Research.

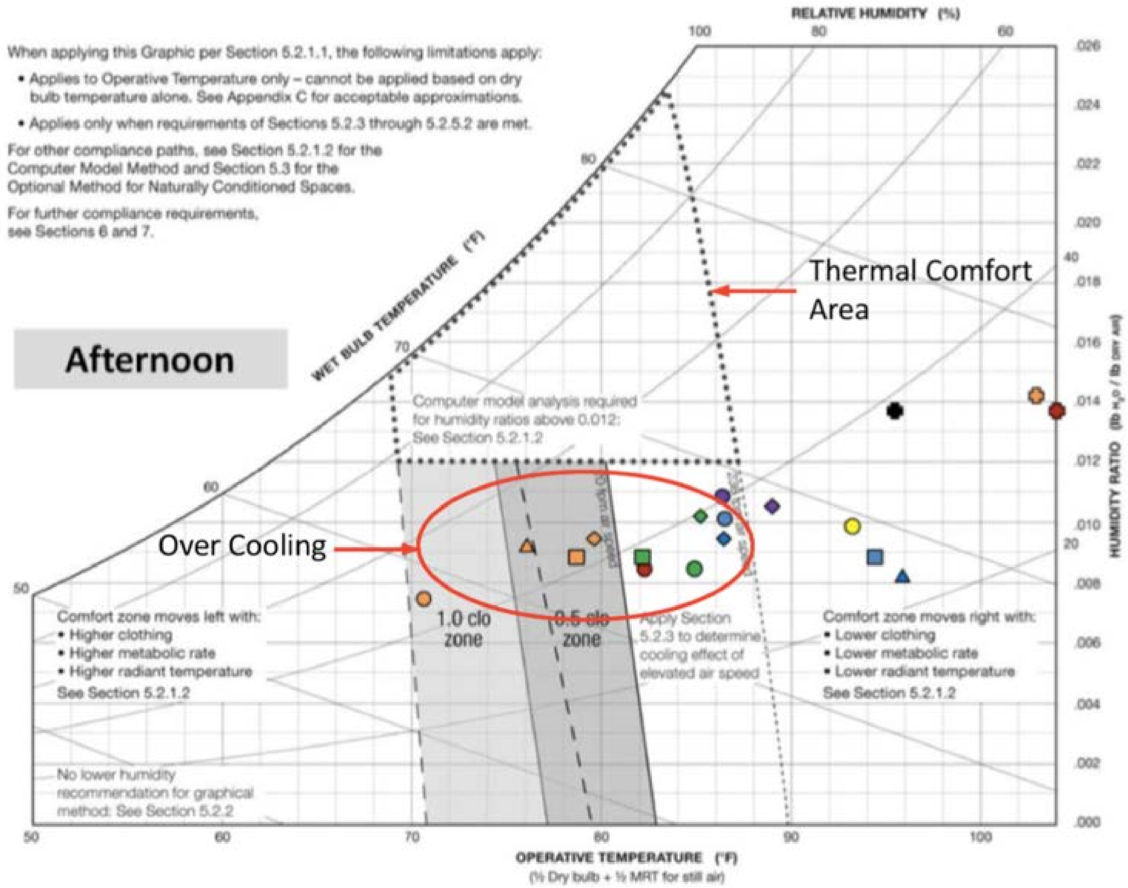
Excessive cooling of workspaces and billeting was a recurring observation related to the employment of ECUs and refers to situations where the temperature and humidity of the occupied space is outside acceptable environmental conditions for 80 percent of the occupants. This scenario was an area of considerable focus for the operational assessment conducted during training exercise Balikatan in the Philippines during April of 2013. The data gathered revealed the over cooling of spaces during late night and afternoon. Figures 8 and 9 illustrate that the majority of the tents were below the American Society of Heating, Refrigeration and Air-Conditioning Engineers thermal comfort area for office spaces and indicates over cooling. These figures consider temperature, humidity and the clothing worn by individuals within the conditioned spaces. The conditions that are acceptable for 80 percent of the occupants is referred to as the thermal comfort area. The thermal comfort area is indicated by a dotted outline and is labeled in Figures 8 and 9. When the temperature and humidity of a space plots to the left or below the thermal comfort area, the space is being excessively cooled.

Figure 8. Late-Night Over Cooling of Spaces



Adapted from U.S. Marine Corps Forces, Pacific Experimentation Center, 2013b, *Transformative Reductions in Operational Energy Consumption (TROPEC)*, Limited Operational Assessment Report – Balikatan, Camp Smith, HI: U.S. Marine Corps Forces, Pacific Experimentation Center.

Figure 9. Afternoon Over Cooling of Spaces



Adapted from U.S. Marine Corps Forces, Pacific Experimentation Center. 2013b. *Transformative Reductions in Operational Energy Consumption (TROPEC)*, Limited Operational Assessment Report – Balikatan, Camp Smith, HI: U.S. Marine Corps Forces, Pacific Experimentation Center.

3. Vehicles

The third category of energy consumers presented in this thesis includes the use and employment of wheeled vehicles. Vehicles provide U.S. Forces with increased maneuver capability enabling the transportation of personnel and supplies. While vehicles amplify the maneuver capability, they require fuel to operate and can consume 70 percent of the fuel required for operating ground units (Shields 2016, 26). Even a fractional reduction in the energy consumed by vehicles can have significant benefits by increasing how long units can operate or maneuver before resupply is required. Observations captured during training exercises conducted at Marine Corps Air-Ground Combat Center (MCAGCC) in Twentynine Palms, CA, identified several scenarios in which vehicles were being inefficiently used and consequently consumed more energy than necessary. The scenarios observed can be grouped in two categories referred to as excessive idling and inefficient vehicle use. A third category worth mentioning that likely exists but was not observed because of the limited data collection methods employed, is that of driving behaviors. Each of these scenarios and corresponding behaviors are presented in the following paragraphs.

Excessive vehicle idling was prevalent throughout the training environment and observed on multiple occasions. In preparation for a tactical logistics convoy, vehicles were idling in excess of 20 minutes. Failure to conduct proper pre combat checks and inspections resulted in an additional 25-minute delay while missing equipment was located (Adamo and Lockhart 2014a, 2). During ITX 5-14 vehicle idling continued to be an issue, especially among the GCE and for larger vehicle movements where "idle times ranged from 30–90 [minutes]" (Adamo and Lockhart 2014d, 2). Still other occasions of idling were observed during WTI 2-14 and ITX 2-14 where Marines were observed sleeping in the air conditioned vehicle cabs for up to two hours (Adamo and Lockhart). While these examples help convey specific situations where prolonged idling occurred, a comprehensive look at vehicle use during seven ITXs from 2013 to 2015 is much more revealing. Instrumenting the MTVRs and logistics vehicle system replacements (LVSRs) used during the training exercises enabled data to be captured which identified information such as vehicle run time, idle time, fuel consumption and mileage. Table 1 reveals that average vehicle idle time for all vehicles listed exceeds 60 percent and reached nearly 78 percent for MRAP vehicle usage. In some instances, vehicle idling may be fully warranted, but the non-interference methods used for observations and data collection did not permit investigation. In spite of this limitation, the observations and data obtained suggest significant opportunity to reduce vehicle idle time and fuel consumption with changes in behavior. For comparison, Table 1 includes the miles per gallon (MPG) without idling for the MTVR as 4.5 MPG and the LVSR as 2.0 MPG (Department of the Navy 2010).

Table 1. ITX Vehicle Data

Vehicle Type	Qty.	Engine hours	Idle hours	Idle Time (%)	Total Fuel (gal)	Idle Fuel (gal)	Idle Fuel (%)	Mileage	MPG with Idling	*MPG Without Idling
MTVR	736	49,301	31,414	63.7	123,322	32,983	26.7	388,315	3.15	4.5
LVSR	108	5,111	3,226	63.1	41,972	5,161	12.3	31,184	0.74	2.0
MRAP	45	2,857	2,219	77.7	4,522	1,553	34.4	11,993	2.65	--
MATV	26	1,523	1,158	76.0	3,875	810	20.9	6,562	1.69	--

*Data from Department of the Navy, 2010, *Principal Technical Characteristics of U.S. Marine Corps Motor Transport Equipment* (TM 11240-ODA), Washington, DC: Headquarters, United States Marine Corps.

Adapted from Naval Surface Warfare Center, Carderock, 2016b, *ITX Vehicle Data*, Washington, DC: USMC Expeditionary Energy Office.

Inefficient vehicle use was also observed on several occasions. This category includes situations where vehicles are used when alternatives exist that would consume less energy or when an inappropriate quantity or mix of vehicles are used for a mission. During ITX 2-14 an MTVR was idled for 20 minutes while Marines used the air compressor associated with the vehicle to remove sand from personal weapons. On another occasion during the same exercise, a fuel resupply convoy was dispatched to satisfy a request for 2,400 gallons of JP-8 but when the vehicles arrived at their destination only a portion of the fuel was dispensed. In this instance, the number of refuelers could have been reduced to save the fuel from the extra vehicle that was dispatched but not needed. The excessive use of resupply convoys was observed during ITX 5-14. When units deployed to forward training areas, resupply was a routine practice, scheduling one or sometimes two trips per day. On some occasions, however, additional resupply missions were conducted when units did not want to wait for the next scheduled run even if it only meant waiting for an additional five hours (Adamo and Lockhart 2014d, 6). Still other instances of inefficient vehicle use were observed from artillery units who would use their MTVRs to recharge the gun system batteries prior to relocating. This is considered an inefficient vehicle use because other assets are available for charging batteries or vehicle charging while moving between locations could be used to reduce vehicle idling.

The third category to be discussed is driving behaviors. Several studies have been conducted and conclude that driving behaviors such as aggressive acceleration and braking can reduce vehicle fuel efficiency. The Applied Research Laboratory at Pennsylvania State University (Penn State ARL) performed a fuel management study of medium and heavy ground tactical vehicles, to include the MTVR, in a controlled test environment. The test evaluated various techniques to improve fuel economy. In August 2014, representatives from Penn State ARL briefed their results indicating that the "impact of erratic accelerator demand and excessive braking by the driver" had detrimental effects on fuel economy and offered a potential benefit of 30 percent in fuel economy improvements (Crow 2014, 2). University of California, Davis (UC Davis) also performed a study of driving behavior. During a naturalistic experiment involving drivers in matched vehicles, fuel economy differences from driving behaviors varied nearly 30 percent among individuals (Kurani, Sanguinetti and Park 2015, 1). While these studies offer no direct correlation to the benefits that could be realized in the USMC operational environment, they do suggest that fuel savings can be realized from changes in driving behaviors. The Marine Corps' Program Manager for Training Systems (PM TRAYSYS) indicated that their operator-driver simulator (ODS) has been successful at influencing changes in driver behavior and has resulted in dramatic improvements in driver safety.

> In 2006 after implementing the vehicle dynamics model for up-armored handling characteristics in the MTVR we saw a drop in driver-error mishap in up-armored vehicles from two accidents per week from the beginning of April when the first up-armored MTVRs arrived at the MCAGCC [EEAP] through the end of May. As soon as we received the software update with the up-armoring handling characteristics and required every driver to train in the ODS and pass all of the scenarios using both regular and up-armored configurations of the MTVR before receiving a trip ticket we saw the driver-error mishap rate aboard [MCAGCC] drop to zero (0) from June – December 2006. (Col. Walt Yates, email message, March 7, 2006).

The results of these three studies present a favorable argument for the potential energy saving benefits that may be realized by influencing driver behaviors.

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V. ANALYSIS AND POTENTIAL SOLUTIONS

The analysis for this research includes an assessment of the behaviors observed and the individual perceptions that are believed to influence energy related behaviors. The assessment is completed while being mindful of the individual Marine and the Marine Corps as an organization as characterized in the USMC Ethos and Organization section of Chapter I. Assessing behaviors and perceptions from the Marine’s perspective ensures that the analysis and conclusions presented in this research are directly applicable at the operational level. Further, this assessment seeks to answer the primary research question by identifying factors that influence human behavior and negatively affect energy consumption in USMC ground units during operations. Once the factors have been identified, the research analysis assesses behavioral change strategies that can be employed as potential solutions. As behavioral change strategies are considered, the author remains mindful of the individual and organization as stakeholders with the intent of identifying strategies that fit and can be successfully integrated within the Marine Corps.

A. BEHAVIORS AND PERCEPTIONS

Chapter IV provides data that illustrates specific examples of behaviors that resulted in the inefficient employment or use of various energy consuming devices. Some of these behaviors included employment of generators well below their design capacity, excessive cooling of tents and excessive vehicle idling. This section attempts to rationalize demonstrated behaviors with perceptions and beliefs identified from surveys, questionnaires and interviews collected in association with Marine Corps training exercises where studies and observations have occurred. The behaviors and perceptions could be considered and broken down in many ways. One approach could have considered behaviors within the various elements of the MAGTF such as the GCE, LCE and CE. To be consistent with the inefficient energy use categories in Chapter IV, the author has elected to group the behaviors and perceptions with the applicable energy consumers: (1) generators, (2) ECUs and (3) vehicles.

1. Generators

The inefficient employment of generators as seen on the battlefield and the training environment indicates they are routinely operated well below their design capacity. Analysis of the data indicates numerous factors that contribute to adverse generator related energy behaviors, including: (1) inadequate power planning and power distribution, (2) excess equipment, and (3) failure to utilize subject matter experts. Each of these factors will be discussed in the following paragraphs.

(1) Inadequate Power Planning and Power Distribution

Power planning for an exercise involves consideration of the electrical loads required to satisfy mission requirements and determination of the appropriate power generation assets to satisfy the needs. During this process, power distribution assets are also considered. Power distribution is a way to disseminate power from one source to many power needs within the immediate vicinity. An example frequently seen was the use of individual generators to power a single tent such as the combined operation center (COC) or logistics operation center (LOC). When this occurs, it is referred to as spot power generation and often results in the generator operating below capacity which is an inefficient use of the generator, creating excess fuel expenditures. Proper power distribution requires pre-planning to ensure facilities are located within relative proximity to be supported by the power distribution assets. The preferred approach is to conduct deliberate planning of the power requirements so power generation and distribution can be appropriately sized for the mission. Regrettably, many units "[rely] on previous unit power planning and site laydown" (Adamo and Lockhart 2014b, 6) rather than assessing their own need. Although relying on previous estimates for required power generation and distribution may satisfy the minimum requirement it falls short of maximizing energy efficiency. Unfortunately, power planning appears to be a facet of the operation that is often neglected.

(2) Excess Equipment

A subsequent result of inadequate power planning is the potential to deploy into an operational environment with either too many or too few assets. With a typical desire for preparedness, excess equipment is more often the outcome. During an interview with an ITX participant, he remarked that more power generation assets are issued from the exercise support division (ESD) than are necessary (Adamo and Lockhart 2014c, 3). This excess enables units to satisfy power requirements without the need to establish energy efficient power planning.

(3) Failure to Utilize Subject Matter Experts.

The responsibility for mobile electric power within the Marine Corps falls under the 11XX utilities MOS designation. The utilities chief and utilities officer are subject matter experts (SMEs) in power planning. As remarked by a utility SME during WTI 2-14, there is a "lack of participation and/or inclusion of utilities or engineer personnel in support of the logistics and operations officer during the mission analysis/problem framing and COA development phases of the planning process" (Adamo and Lockhart 2014b, 6). The use of these SMEs during exercise planning would provide unit commanders with information and options regarding how power needs can be met in an energy efficient manner with the potential to reduce the quantity of generators employed. The effect would be reduced energy consumption with fewer assets. Fewer assets result in a lighter, more agile operating force while greater fuel efficiency improves operational reach and self-sustainment. An opportunity exists within the USMC training environment such as WTI and ITX to incorporate logistics aspects such as power planning. As it stands, power planning is not a graded event and therefore appears to receive little attention, if any.

2. Environmental Control Units

The inefficient employment of ECUs was a common observation during exercises Balikatan, Cobra Gold, ITX and others. Often times spaces were cooled to excess or the spaces being conditioned had openings that allowed conditioned air to escape, diminishing the ECU's effectiveness and wasting energy (Adamo and Lockhart 2014a, 1–2). Analysis of the data indicates the prevailing behaviors believed responsible for these adverse ECU related energy behaviors include: (1) poor awareness of the impact practices have on energy expenditures, and (2) inattention of leadership. Each of these factors will be discussed in the following paragraphs.

(1) Poor Awareness of the Impact Practices have on Energy Expenditures

Environmental control units require electricity which in turn require fuel for operation. It appears likely that these behaviors result from the belief that fuel as a commodity will always be available. If unit training included a constraint on available fuel, more efficient and conservative employment may be realized.

(2) Inattention of Leadership

ECUs contribute significantly to personal comfort and to a lesser extent mission effectiveness. It is therefore believed that Marine Corps leadership can influence behaviors by monitoring and managing the efficient employment of ECUs and eliminating their use when employment conditions are inappropriate. To help the effectiveness of leadership, the impact of inefficient use will need to be quantified and communicated to heighten the awareness of the negative impact improper ECU employment has on energy consumption resulting in reduced fuel for more critical aspects of mission performance.

Similar to power planning, significant opportunity exists to reduce the energy consumed by ECUs. Education is considered a necessary aspect for improving the understanding and awareness that inefficient ECU employment has on energy consumption in the operating environment. In addition to education, leadership has a role to play.

3. Vehicles

The final category of inefficient energy behaviors analyzed in this thesis is associated with vehicle use. Modeling and simulation of energy consumption in small unit scenarios indicates that vehicles can consume as much as 70 percent of the total fuel required for ground unit operations (Shields 2016, 26). This quantity is significant in many ways and can create operational and logistical challenges in addition to financial burdens. Analysis of the data indicates numerous factors that contribute to adverse vehicle related energy behaviors to include: (1) lack of confidence in equipment, (2) perception of plenty, (3) poor understanding of the impact idling has on fuel consumption and (4) incidental operators. Each of these factors will be discussed in the following paragraphs.

(1) Lack of Confidence in Equipment

On several occasions, poor confidence in equipment resulted in vehicle idling. The equipment used by training units at ITX is provided by the ESD from the enhanced equipment allowance pool (EEAP). Since the EEAP is located at MCAGCC, transportation costs are avoided, but the equipment experiences accelerated wear from frequent use during ITX. Although the equipment receives the requisite maintenance, operators and unit commanders are sometimes concerned with the condition of the equipment and are leery of reliability. This lack of confidence was expressed for vehicles and artillery gun batteries. For vehicles, the risk of reliability appears to be mitigated by starting vehicles before scheduled departure to ensure they are operational and ready to move. The down side is that the vehicles are left to idle before the scheduled movement. While the concern and mitigation employed is reasonable, it may not be justified. Observations conducted during seven ITXs have failed to capture any accounts of vehicle idling due to a vehicle failing to start and causing the delay of movement and associated idling. Similar reliability or performance concerns exist for the howitzer gun batteries and their ability to maintain a charge. As a mitigation, the MTVRs are used as a power source to charge the batteries which requires the MTVR to be running at idle. Although using the MTVR is a viable option to recharge the batteries, alternate more efficient methods exist which include using more fuel conservative generators or using the vehicles to charge the batteries enroute to their destination rather than additional idling before movement. In both instances, poor confidence in equipment appears to have been a contributing factor to the resultant behavior. In the case of vehicle reliability, the concern is not supported by the data available. Concerning the howitzer batteries, the behavior or decision to charge the batteries appears justified but failure to use more energy efficient methods for charging suggest a lack of awareness of the impact.

(2) Perception of Plenty

In support of the ITX, vehicles are issued to training units from the EEAP. An interview conducted with an ITX 3-14 participant indicated that CLB-1 had more vehicles than were required and as a result "provided GCE units with lift on demand" (Adamo and Lockhart 2014c, 7). There is no argument that the desire is for U.S. Forces to have the ability to operate and maneuver in a manner that is most advantageous to the mission. The problem occurs when assets are issued in surplus, and commodities such as fuel are unconstrained creating the perception of abundance. This mindset appears contrary to the USMC character of being an agile and self-sufficient fighting force. In the presentation of data, the author identified examples of inefficient use of resupply missions. Some resupply runs were conducted for perceived convenience rather than waiting for regularly scheduled trips. Others requested more supplies than could be accommodated on the receiving end, resulting in needless fuel expenditures and tying up assets that could be used more productively elsewhere. The abundance of equipment or perception of plenty diminishes the need for more thoughtful and deliberate planning and consequently, often results in unnecessary fuel consumption.

(3) Poor Understanding of the Impact Idling has on Fuel Consumption

Individuals are often unaware of the impact behaviors have on energy consumption. The apparent lack of knowledge or awareness of these adverse effects appear to be a common factor with inefficient vehicle use. The data presented in Table 1 illustrates that over the course of seven separate training exercises vehicle idling of the larger vehicles resulted in the consumption of over 40,000 gallons and accounts for nearly 25 percent of the fuel used in the vehicles. An interview conducted with an ITX participant by Salem and Gallenson (2014, 31) indicated that "idling is just the cost of doing business." The author agrees that vehicle idling is to some extent unavoidable, but data from Table 1 reveals that on average, over 60 percent of the time vehicles are run, they are at idle suggests significant opportunity exists to conserve fuel. To provide context, a 25 percent reduction in idle time would save 10,000 gallons of fuel and a 50 percent reduction would provide sufficient savings to fuel vehicles for an entire ITX evolution. Communicating the potential benefits of reduced vehicle idling will help improve awareness and may convey that potential savings from reduced idling are not trivial and can help improve self-sufficiency of the operating force and increase operational reach with extended maneuver capability.

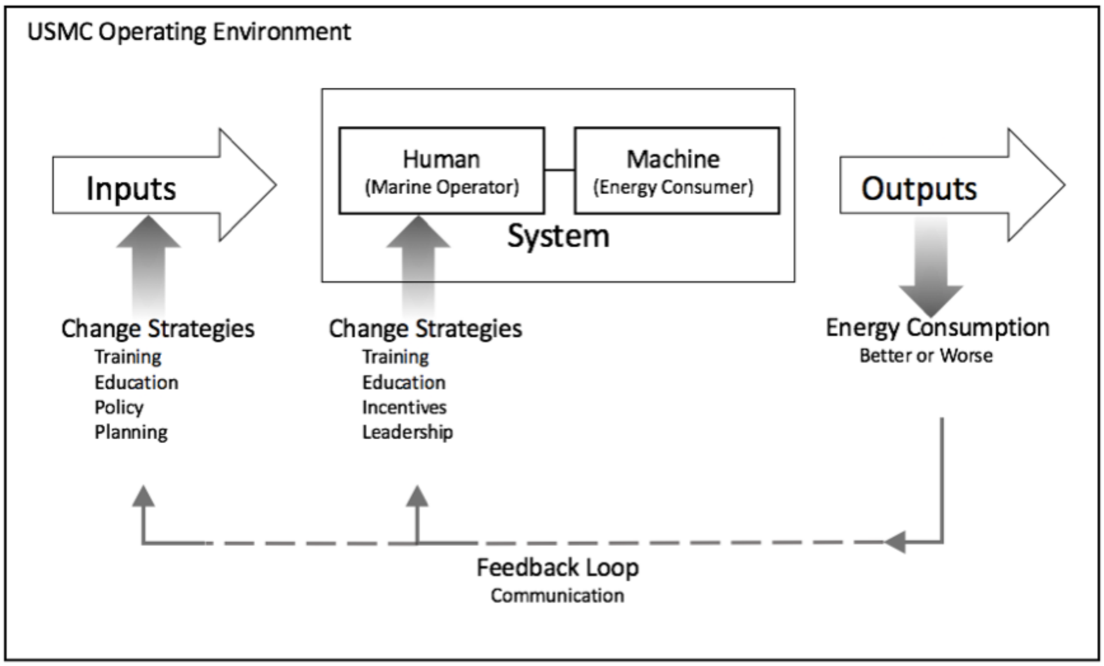
(4) Incidental Operators

Many of the drivers in the operating units are licensed as incidental operators. An incidental operator is qualified to drive but driving is not the primary specialty for that Marine. The training received by incidental operators is less comprehensive than for Marines with the 353X motor transport driver designation. Discussion with members of the 35XX community during ITX 5-14 indicate that incidental vehicle operators are less likely to comply with best driving practices and are more prone to “gunning the vehicle during short movements and heaving breaking” (Adamo and Lockhart 2014d, 7). The study by Penn State ARL indicated that “an aggressive driving posture decreased [fuel] efficiency by at least 1 MPG (28%)” (Crow 2014, 3). The perceived contributing factor is that incidental vehicle operators are unaware how significant an impact driver behavior can have on fuel consumption.

B. POTENTIAL SOLUTIONS

The analysis of behaviors and perceptions reveals there are many factors contributing to the various behaviors observed. Fortunately, there are several strategies that appear well suited for application in the Marine Corps and may result in reduced energy consumption from positive behavioral changes. Recall that Chapter I presented three approaches to implementing organizational change which included organizational factors, individual factors, and behavioral change strategies. Accordingly, this research proposes an altered organizational focus to address organizational factors that places attention on the individual Marine as the individual factor by prescribing mechanisms for communication, leadership, and training and education as behavioral change strategies to improve energy efficiency. Specifically, the strategies applicable to the Marine Corps include training and education, policy and planning, leadership and communication. Figure 10 represents a simple process model developed by the author to illustrate how the various strategies may be applied or integrated within the Marine Corps to improve energy related behaviors.

Figure 10. Human-Machine System Process



The figure as a whole represents the Marine Corps and the operational environment. At the center is the human-machine system which represents the Marine operator and the energy consuming device. In the current state, the Marine operates the system based on current knowledge and beliefs. The data presented in Chapter IV is representative of the output associated with the current state and indicates the Marine operator has a generally poor awareness or perhaps complacency regarding the impact his behaviors have on energy consumption. As change strategies are employed within the USMC to address energy goals, they act as inputs to the system with the intent of influencing behaviors. The inputs can take many forms and may include general approaches such as training and education. Initially, USMC leadership is anticipated to be the subject of the training and education and the resultant input to the human-machine system will be in the form of energy related standard operating procedures (SOPs) and tactics, techniques and procedures (TTPs). With new inputs, the corresponding and desired impact is changed behaviors that result in improved energy efficiency as the output. An important element that must be incorporated following the input is reinforcement of the desired behavior change. Reinforcement requires clear and consistent communication of the importance of energy efficiencies by leadership and through supervision. Analysis of the output determines if the inputs have had the desired positive effect. For the sake of discussion, we assume the output has achieved an incremental improvement. As part of the feedback loop the improvement is communicated back to the beginning of the process and to the system operator where additional or revised inputs are implemented. This process model also affords the opportunity for the Marine operator to receive training and education to obtain a richer, first-hand understanding and heightened awareness of how his behavior can have a positive impact on mission effectiveness by reducing energy expenditures. The energy change strategy matures as the organization and individuals begin to modify their behaviors to reduce needless energy expenditures. In time, and with continued focus on energy related behaviors, the outputs can reveal measurable improvements that justify the change strategy efforts. The ultimate goal for the future state of the process model and Marine Corps is increased fuel efficiency without affecting mission performance. Key to the success of the energy change strategy is persistence at all phases and stages of the process.

1. Training and Education

Training and education are two related behavior change strategies that differ in the degree of knowledge imparted to the individual. Both are necessary to communicate the importance of improved energy efficiency in the operational environment. Fortunately, the Marine Corps already embraces both of these strategies to develop awareness, skills and abilities during the course of individual careers throughout the organization. From the first day of either Basic Training or Officer Candidate School, prospective Marines receive both training and education, which provides the tools and skills necessary to contribute to the successful operation of the organization. Therefore, it seems appropriate that Marines receive both education and training regarding the importance of effective and efficient energy use at this early stage of development, just as they would for the use and employment of tactics and weapon systems to successfully complete assigned missions. Each step of career progression for Marines, from MOS school to intermediate and advanced schools provides an opportunity to convey the importance of effective energy use. Training and education are considered to be vital components to the change strategy if significant improvements to energy related behaviors are to be realized.

2. Policy and Planning

The Marine Corps has already taken the first step forward regarding energy use within the organization by conceding that improvements can and must be made. Overarching goals such as "increase[ing] energy efficiency of weapons systems, platforms, vehicles, and equipment [by 40 percent by 2020]" (United States Marine Corps 2011, 22) have been established and improvements to fielded equipment are being realized with more fuel efficient generators, thermal liners for tents and renewable energy assets that harvest and convert solar energy into electrical energy. While these actions are noteworthy and undoubtedly help achieve improved fuel efficiencies, they do not address the significant impact that human behavior has on energy consumption. Additional improvements can be realized by including behavior related aspects of energy consumption as a component of the Marine Corps' energy objectives. Two aspects in particular, power planning and energy related SOPs were either infrequently used or in the case of energy related SOPs, often did not exist. The use of Marine Corps utility officers and chiefs during mission planning and execution, combined with implementation of unit level SOPs regarding energy use behaviors is likely to yield measureable improvements in operational energy efficiencies without adversely impacting mission effectiveness.

3. Leadership

Leadership at all levels is an important element that ensures the disciplined and effective operation of the Marine Corps. For the energy change strategy, leadership must be an integral part of the foundation if positive and lasting change is to be realized. When policy has been established and education, training and planning have occurred, success will hinge on Marine Corps leadership to keep their Marines informed of the importance of sound and efficient energy practices, lead by example, and ensure responsibility and accountability are maintained. The success of many behavior change strategies rely on the coordinated application of several techniques as no single approach can satisfy all situations. The Marine Corps' return to its expeditionary roots as a fast, austere and lethal force will depend on its effective management of energy and the use of leadership to communicate the importance of energy related behavior change.

4. Communication

The ability to communicate the benefits that can be realized with improved energy efficiency is critical if an enduring culture change of increased energy efficient behaviors and practices is to occur. By communicating the benefits that can be obtained in terms that Marines can relate to such as increased days of self-sufficient operations, additional miles of maneuver capability or casualties avoided from resupply missions, the likelihood that enduring behavior changes occur increases. The feedback loop illustrated in Figure 10 is a mechanism to communicate the effects that behavior changes have on energy consumption. Changing individual behaviors to reduce negative effects on energy consumption will require focus and persistent effort. If a value is not perceived from the effort and changes, it is unlikely that enduring energy related behaviors will occur.

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VI. CONCLUSIONS

The Marine Corps' return to its expeditionary posture as a fast, austere and lethal force requires that it come to terms with energy consumption. Advances in equipment alone overlook a tremendous opportunity. The data presented in this thesis indicates significant energy savings can be obtained through a concerted effort and behavior change strategy that includes training and education, policy and planning, leadership and communication to improve individual and organizational awareness of the importance of efficient and effective use of energy. In particular, opportunities are available for significant improvement in the use and employment of generators, ECUs and vehicles. Energy related behavior changes within the operational environment can have a positive impact in several areas to include improved energy security, greater self-sufficiency, increased operational reach and fewer casualties from force protection of fuel resupply convoys.

A. ANSWERS TO RESEARCH QUESTIONS

This purpose of this thesis is to assess the factors that influence behaviors within the Marine Corps and adversely affect energy consumption. The research questions from Chapter I are revisited below with summary answers.

1. What are the factors that influence human behavior and negatively affect energy consumption in USMC ground units during operations? This question is answered by grouping the factors with the associated or corresponding equipment. Factors associated with the employment of generators include: (1) inadequate power planning and power distribution, (2) excess equipment, and (3) failure to utilize subject matter experts. Factors associated with the use of ECUs include: (1) poor awareness of the impact practices have on energy expenditures, and (2) inattention of leadership. Factors associated with vehicles include: (1) lack of confidence in equipment, (2) perception of plenty, (3) poor understanding of the impact idling has on fuel consumption and (4) incidental operators.

2. Can behavior based energy savings be realized without sacrificing mission performance? Yes, the information encountered in this research effort supports a conclusion that energy savings can be realized without an adverse impact on performance.

3. What benefits can be realized by changing human behavior to avoid unnecessary energy expenditures? The benefits that are possible from changes in behavior include improved energy security, greater self-sufficiency, increased operational reach and fewer casualties from force protection of fuel resupply convoys

B. RECOMMENDATIONS

There are many strategies available to effect change within an organization. This thesis has looked at energy related behaviors within the Marine Corps and has considered the strategies and actions that are considered appropriate for the organization and have significant potential for influencing behaviors. The recommended actions for consideration include: (1) schoolhouse training and education of energy related behaviors, (2) train like you fight and (3) develop unit level SOPs for energy efficient practices.

(1) Schoolhouse Training and Education of Energy Related Behaviors

Use of the existing Marine Corps schools is an opportunity to insert periods of instruction regarding the importance of efficient energy practices. Incorporation of this material does not need to extend or replace existing course instruction. Rather, incorporating and communicating the positive benefits that efficient and effective employment of the systems and tactics already being taught will begin to improve awareness and can lead to improved energy related behaviors.

(2) Train Like You Fight

A perceived opportunity that is being missed is the evaluation of the logistics aspects of training exercises to include power planning and the energy efficient employment of assets. The primary focus of the training does not and should not be on logistics but avoiding this important operational consideration is not training in the same way the Marine Corps intends to fight if it is earnestly trying to reduce energy consumption in the operational environment and return to its expeditionary posture. Evaluating the logistics operations of the training units will require leadership to assess what equipment and practices are necessary to accomplish the mission and discern what is surplus or bloat.

(3) Develop Unit Level SOPs for Energy Efficient Practices

Marines have many things to focus on during training and real world operations. The likelihood that energy conservation practices are not among their top priorities should come as no surprise. One of the recommendations to help Marines stay mindful of energy related behaviors and the operational benefits they can provide is the development of energy related SOPs. Establishment of these SOPs is intended to be a persistent reminder to Marines and leaders alike that energy on the battlefield is an enabler in much the same way that ammunition and rations are essential for the successful completion of the mission. The development of unit level SOPs for energy efficient practices is strongly encouraged.

C. AREAS FOR FURTHER RESEARCH

The research completed for this thesis resulted in a qualitative determination of several factors that influence energy related behaviors. While some behaviors are more prevalent than others and suggest where efforts should be applied, it is not known which behaviors result in the greatest although needless energy expenditures. Further research that quantifies the impact of these various behaviors would enable Marine Corps leadership to begin focusing on areas where the greatest benefits can be realized. As discussed in the thesis, communication of the benefits that energy related behaviors can achieve is considered critical; being able to do so in quantitative terms is more likely to convey the inherent value of the behavior changes.

A second area for further research includes investigation of the different change strategies that can be implemented to determine which approaches can be most influential. Although some efforts such as development of energy related SOPs may be implemented more quickly or with less effort it is unlikely that all of the recommendations presented in this thesis can be applied simultaneously. Understanding which change strategies will produce the greatest initial results will help decision makers prioritize efforts.

One additional area recommended for further research is an investigation of how energy related behaviors vary between MAGTF elements and military occupational specialties. There is a general sense from the literature reviewed during the course of this research that supporting units such as the LCE and the 11XX utilities occupational field may have a greater appreciation for the importance of energy in the operational environment. Further understanding of how units and MOSs differ in their perception of the importance of energy will assist USMC leadership establish focused training and education opportunities throughout the Marine Corps with appropriate content and scope for the intended audience.

APPENDIX

The following table captures some of the observed behaviors from Marine Corps training exercises in addition to comments obtained from participating individuals via surveys or interviews.

Behavior	Contributing Factor(s)	Scenario	Source
Vehicle idling	Awareness, training, leadership	Idling in motor pool before departure	ITX 2-14
Vehicle idling	Awareness, leadership	Idling vehicle to run air conditioner	ITX 2-14
Vehicle idling	Training, leadership	Failure to conduct proper PCCs and PCI	ITX 2-14
Vehicle use	Planning, awareness	Resupply request of 2,400 gallons but only 1,600 gallons could be accommodated	ITX 2-14
Vehicle use	Awareness, leadership	MTVR run at idle so Marines could use air compressor to remove sand from personal weapons	ITX 2-14
Vehicle idling	Planning, leadership	Idling to correct vehicle order of march before departure	ITX 2-14
Poor power planning	Planning, awareness leadership,	Two separate generators employed, both underutilized. Power distribution could have eliminated the need for one of the generators (multiple occurrences)	ITX 2-14
Inefficient cooling	Awareness, leadership	ECUs connected to building with flex tubing through window without insulation to seal insertion point	ITX 2-14
Vehicle use	Awareness, planning	MTVR run at idle to charge gun batteries	ITX 2-14
Poor power planning	Training	1169s not as well trained in power planning in expeditionary environment	WTI 2-14
Idling, Driving behaviors	Leadership, training, awareness	Fuel efficiency is METT-T dependent. No SOPs or TTPs on hand	WTI 2-14
Poor power planning	Training	Lack of dedicated training at formal schools, specifically the Engineer and Logistics Officer Course	WTI 2-14
Poor power planning	Planning, awareness	Limited staff integration during the planning process	WTI 2-14
Excess equipment	Planning, leadership	Excess generators issued from ESD	ITX 3-14
Vehicle idling	Awareness	Vehicle idling, 5 – 25 minutes in motor pool before departure	ITX 3-14
Power Planning	Leadership	Initial power plan not executable because of changed site layout. SMEs not engaged to modify power plan	ITX 3-14

Behavior	Contributing Factor(s)	Scenario	Source
Vehicle use	Awareness, planning	MTVR run at idle to charge gun batteries	ITX 3-14
Poor Power planning	Planning, leadership	Generators underutilize at HQ COC and Maintenance area. 10 kW generator used at less than 10% capacity, 30 kW generator used at less than 30% capacity	ITX 3-14
Power planning	Planning, leadership	No power plan developed. 30 kW generator used to support single tent with ECU. Generator was significantly underutilized	ITX 3-14
Excess equipment	Planning, leadership	Unit had excess capacity of vehicles which provided units with lift on demand	ITX 3-14
Vehicle idling	Planning, leadership	Vehicle idling from 30–90 minutes resulting from poor planning and miscommunication	ITX 5-14
Power planning	Planning	Observed limited used of MEPDIS-R (power distribution) at Camp Wilson.	ITX 5-14
Driving behaviors	Training, awareness, leadership	Incidental drivers	ITX 5-14
Vehicle use	Leadership	Unit kept crew-served weapons mounted to vehicles overnight requiring a fire watch. Marines assigned fire watch duty often sat inside running vehicle to take advantage of air conditioning	ITX 5-14
Vehicle use	Planning, leadership	Improper PCCs and PCIs resulted in unit failure to take enough water to retransmission site resulting in emergency resupply of water	ITX 5-14
Generator use	Planning, leadership	60 kW generator grossly underutilized powering single ECU and tent with one laptop and personal electronic devices	ITX 5-14
ECU employment	Planning, awareness and leadership	ECU ventilation ducts placed in windows and doorways of facilities at Camp Wilson with unsatisfactory job in sealing gaps	ITX 5-14
Equipment use	Planning, awareness and leadership	No indication of radiant barrier use	ITX 5-14
ECU employment	Awareness, leadership	Motor pools had completely open hatches with ECUs running	ITX 5-14
Excess equipment	Planning	Limited interaction with ESD before ITX resulted in overdrawing of equipment based on previous ITX usage	ITX 5-14
Vehicle use	Planning, leadership	GCE typically requests more fuel than needed which results in the CLB having to acquire extra fuel and sending vehicles to refuel location that needed.	ITX 5-14
Vehicle use	Awareness, leadership	Use of vehicles for ad hoc missions around Camp Wilson that could be conducted without vehicles	ITX 5-14
Generator employment	Awareness, planning and leadership	On average, generators ran at 34% capacity	Cobra Gold 2013
ECU employment	Awareness, leadership	Tent flaps were opened in the morning hours because it got “too cold” in the COC	Cobra Gold 2013

Behavior	Contributing Factor(s)	Scenario	Source
ECU employment	Awareness, planning	Excessive ECU duct length resulted in large temperature rise between the supply end and the distribution end	Balikatan 2013
Tent liner employment	Awareness	Radian barrier alone reduced ECU energy consumption by 7.0 percent	Balikatan 2013
Occupancy sensing thermostat employment	Awareness	Occupancy sensing thermostats reduced ECU energy consumption by 9.5 percent in shelters not equipped with radiant barriers.	Balikatan 2013
ECU employment	Awareness, leadership	ECUs were used at night dropping indoor temperature to as low as 55 degrees in spite of outdoor temperatures being within ASHRAE comfort zone	Balikatan 2013
ECU employment	Training	ECU thermostats typically not adjusted once they are initially set	Balikatan 2013

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